A new Modular and Open Concept for the Maritime Integrated PNT System

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PNT

P = Position

N = Navigation

T = Time

PNT System	**→ ashore & aboard components for navigation**
PNT Module	**→ one part of the INS for navigation reletad issues**
PNT Unit	**→ the kernal (SW) of the PNT module**

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Safe Navigation under all conditions – The main questions



What is the **position**, **velocity** and **course** of my own **vessel**?

Where are the **other vessels** and do they crossing my route?

Are there other **obstacles** along the fairway?

How reliable are these information?

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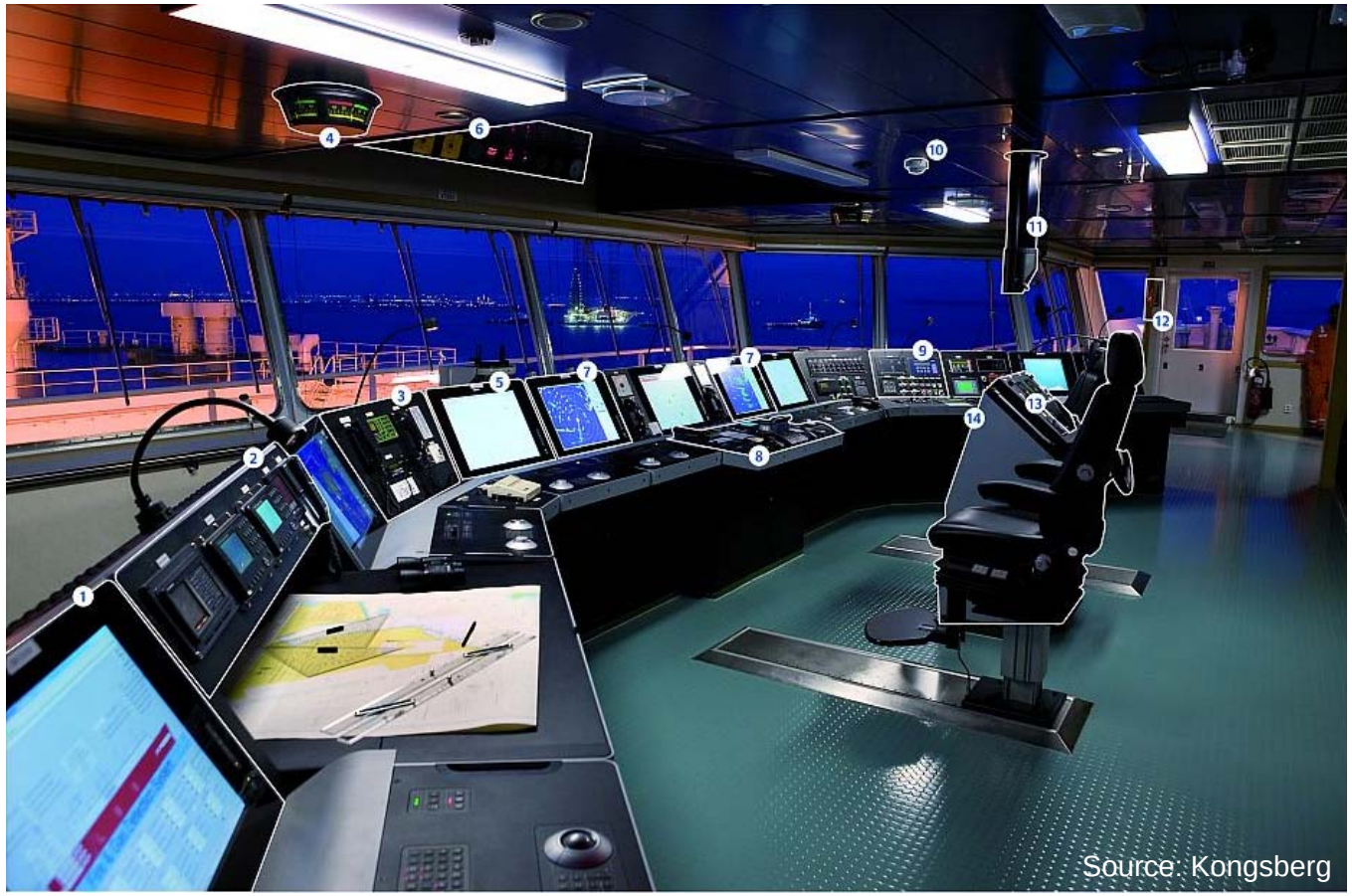
The Modern Bridge



- Fire Detection Panel
- GPS
- SpeedLog
- Rudder Angle Indicator
- ECDIS
- Echosounder
- Radar
- Engine Controls
- Switch Panels
- AIS
- Magnetic Compass
- SAR-Transponder
- Gyro Compass

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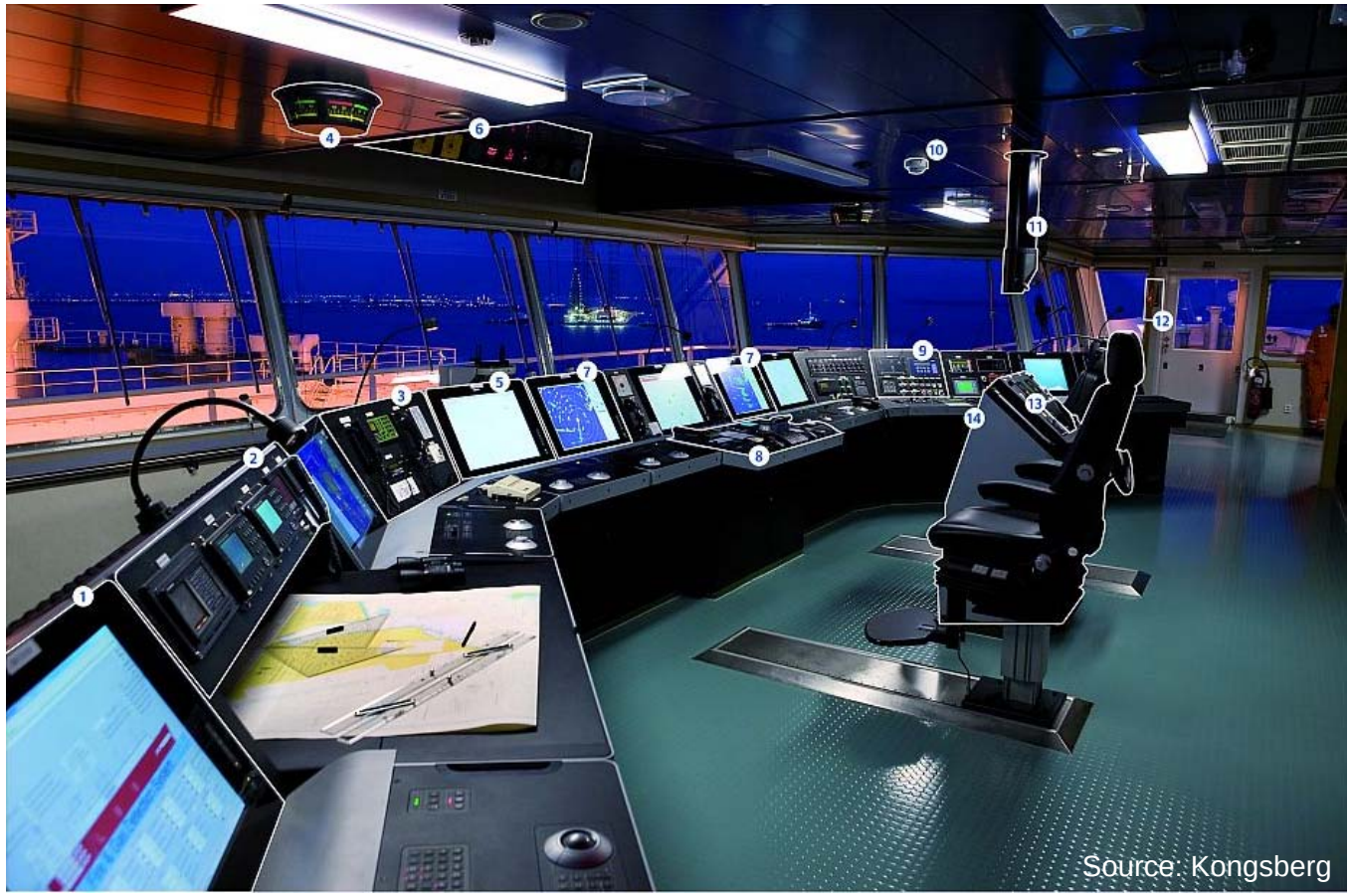
Navigation related Sensors on the Modern Bridge



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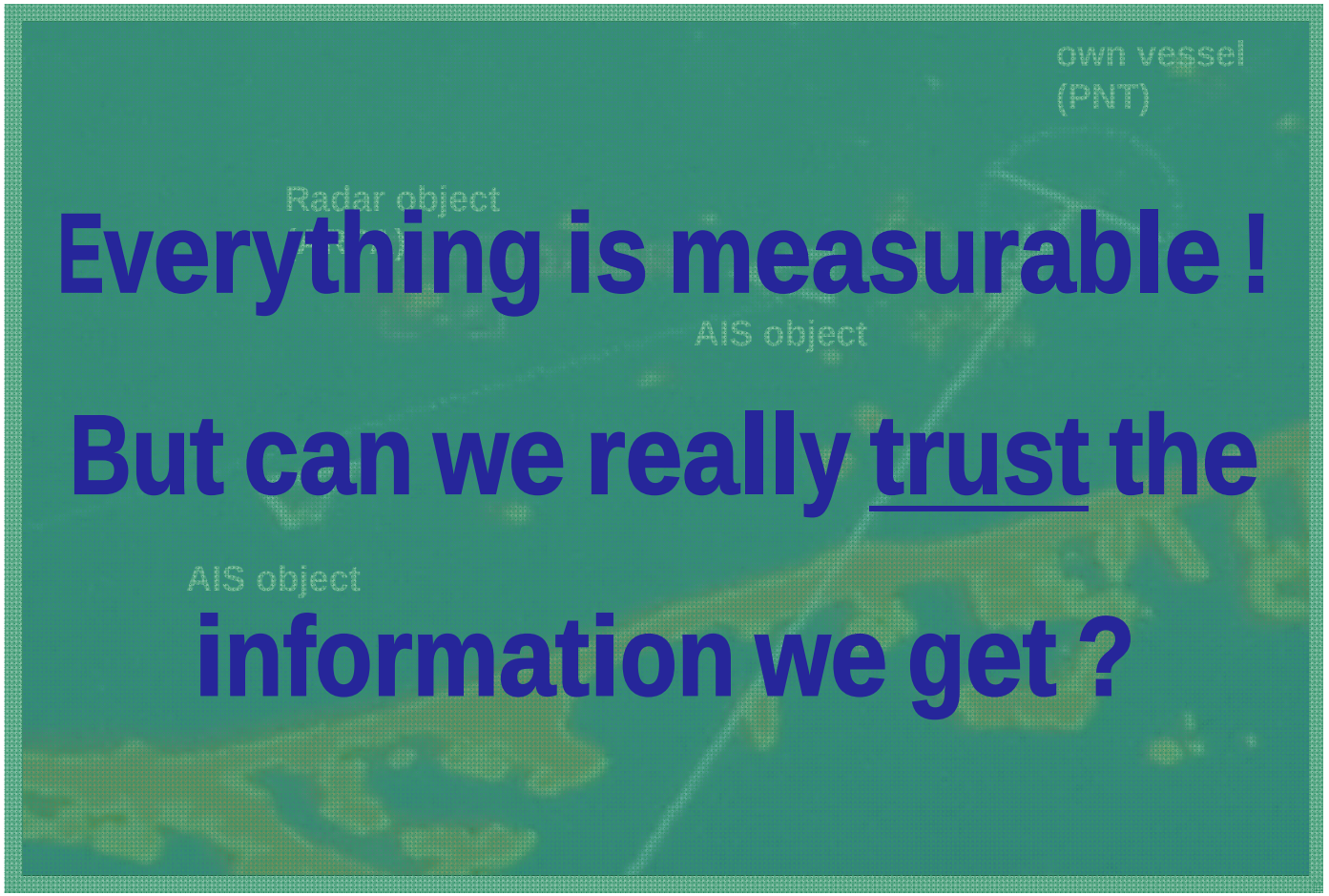
Navigation related Parameters on the Modern Bridge



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Challenges

Higher Transport volume leads to increasing traffic densities and increasing vessel size with higher potential in collision and groundings.

Around **20%** of accidents are induced by technical factors*

Reasons are
- **malfunctions** and **errors** in nautical systems
- **imprecise, incomplete or falsified** provision of **nautical information**
- **misinterpretations** of navigation relevant data

* Source: HELCOM Report on shipping accidents in the Baltic Sea area during 2011

Consolidated technical specification of user needs

Reliability should be measurable and scalable!

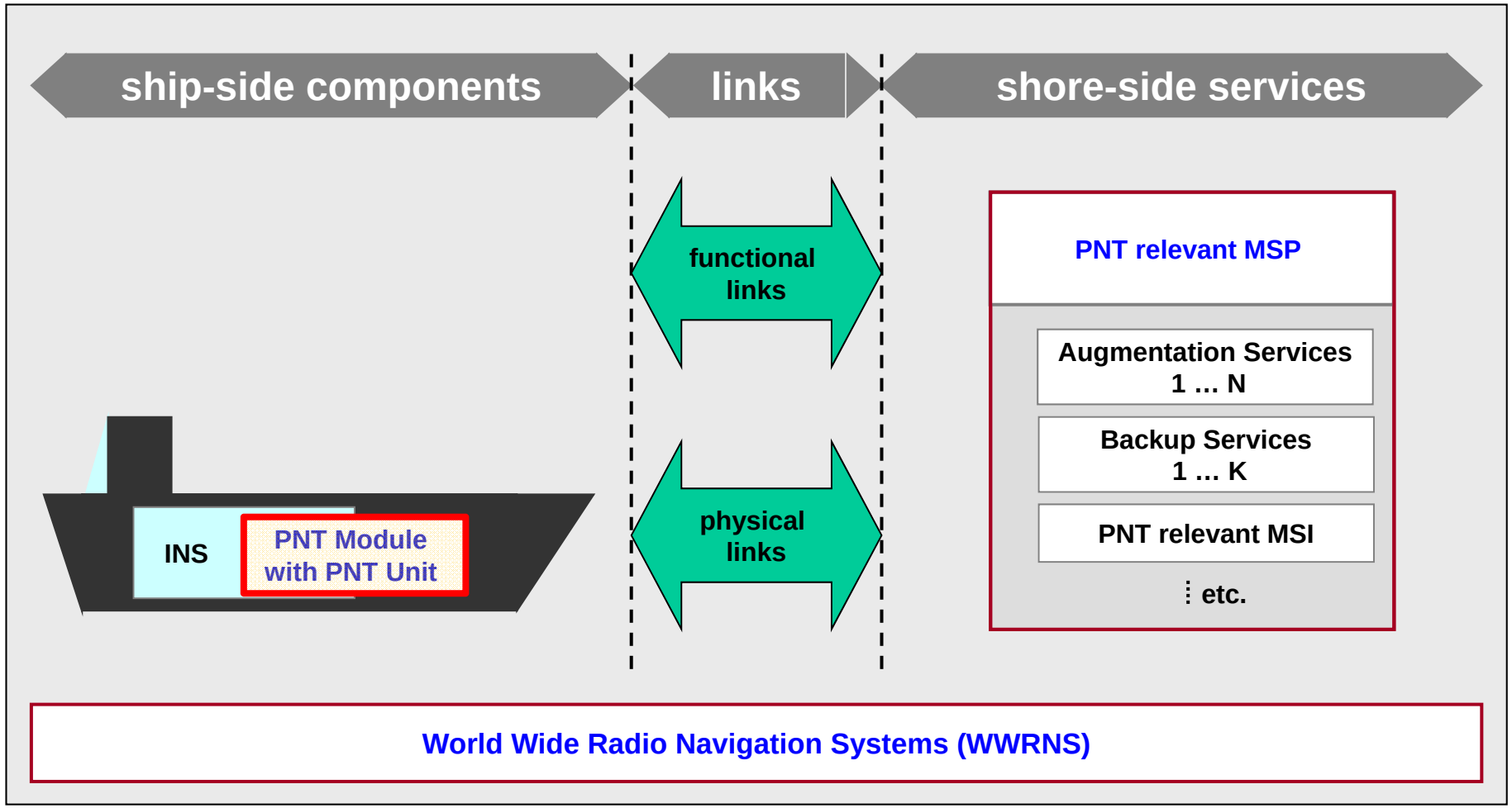
IMO MSC.233(83) intends the application of **RAIM** to assess the GNSS based provision of PVT data.

The INS (IMO MSC.252(83); IEC 61924) applies **plausibility and consistency checks** to assess the PNT data provided by several ship-side sensors.

IMO A.915(22) specifies **minimum requirements** on horizontal position data given in unambiguous **terms of accuracy, integrity, continuity and availability**.

- Harmonized meaning of integrity information
- Management of integrity within systems operating with distributed components and services
- Equivalent specifications for other navigational data (e.g. SOG, STW, ROT, Heading, …)
- Crossover from minimum to scalable requirements (accuracy, integrity) by consideration of specific tasks and their temporal and spatial dependencies

Generic Architecture of the whole PNT System



The PNT Portfolio

Global Navigation Satellite Systems: GPS | GLONASS | GALILEO | .....

Satellite Based Augmentation Systems: WAAS | EGNOS | Beidou | ....

ship-board

Integrated PNT Module

Multi-System Radio Navigation Receiver
(Core PNT Sensor)

- GNSS Receiver*
- GNSS/SBAS Receiver*
- Integrated GNSS/ DGNSS Receiver*
- Integrated GNSS/ Backup Receiver*

**Could be included in AIS device, need of raw data*

Standard Navigation Sensors
- Gyro Compass
- SDME
- Radar Map Matching
- ROT Indicator
- .....

Additional Navigation Sensors
- IMU
- Echo Sounder
- ePelorus
- .....

PNT Unit**
(Value-added data processing system)

Output: PNT data + Integrity data
(Consistent Common Reference)

P + I | N + I | T + I | A + S

shore-based

Terrestrial Augmentation Services
- IALA Beacon DGNSS AIS DGNSS
- M-GBAS (RTK) ?
- .....

Terrestrial Backup Services
- eLoran
- R-Mode
- .....

PNT part of Maritime Service Portfolio (MSP)

** *fusion of all sensor and service data will be realised by PNT Unit*

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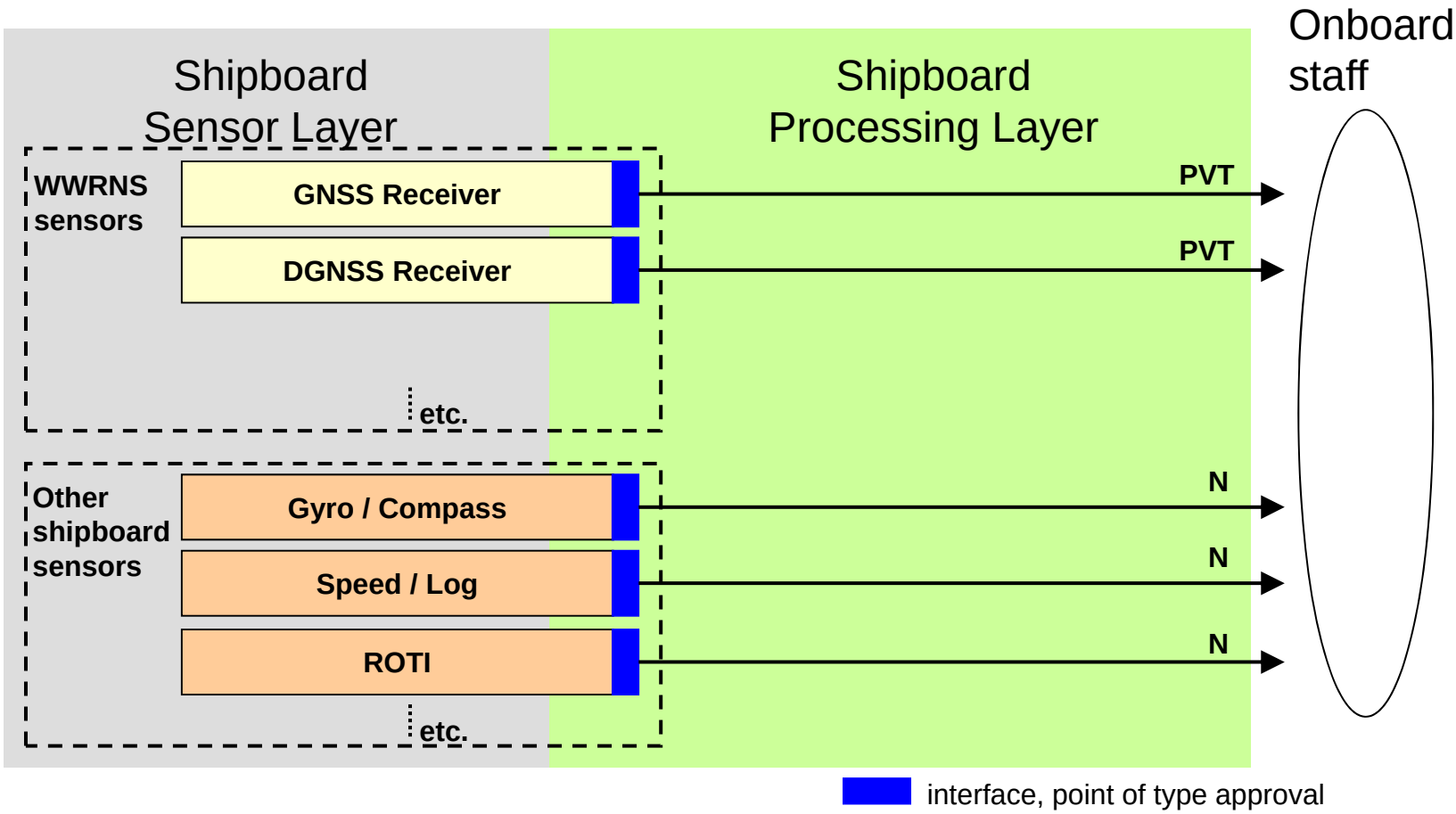
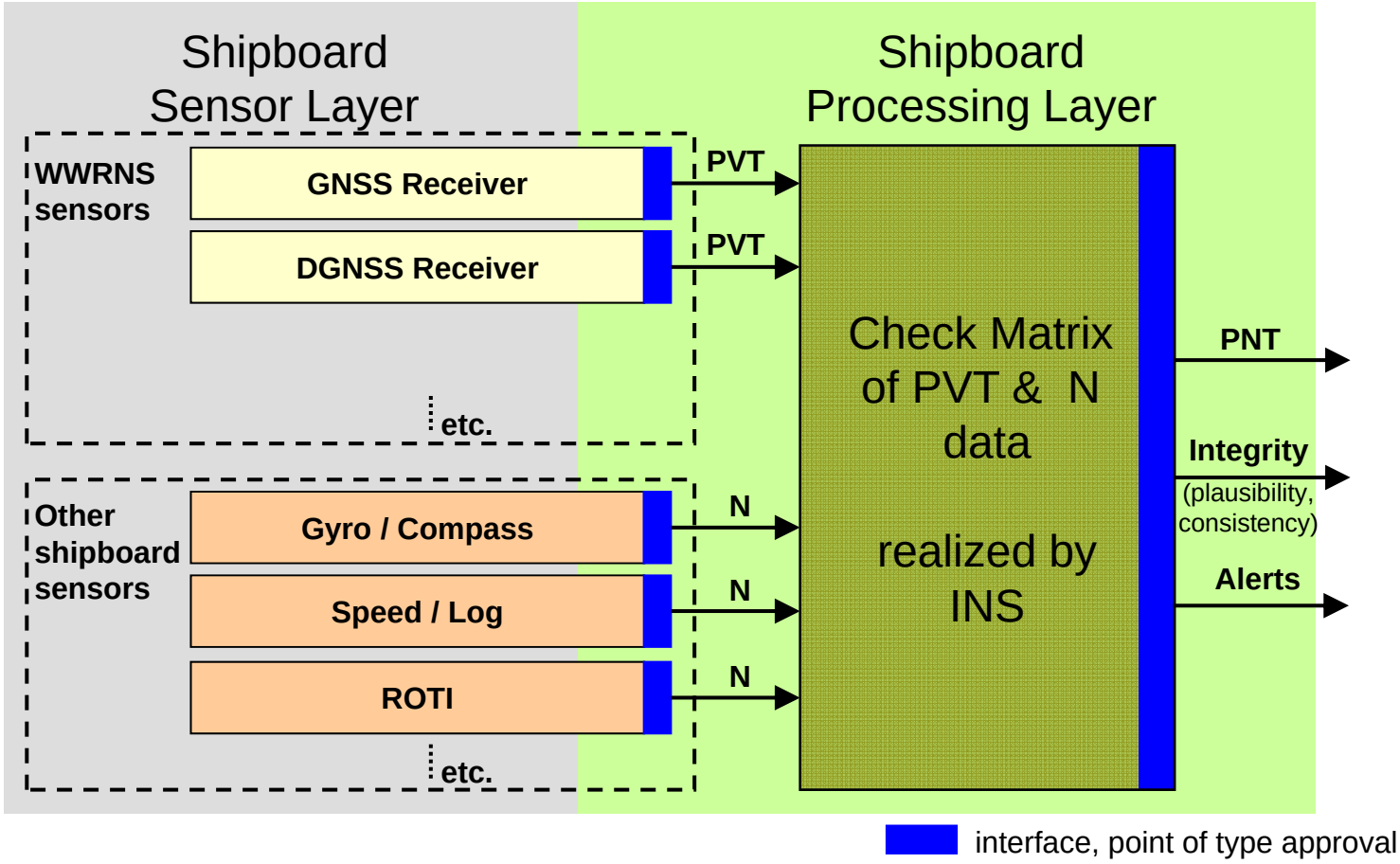
Current approach 1: single sensor based PNT determination



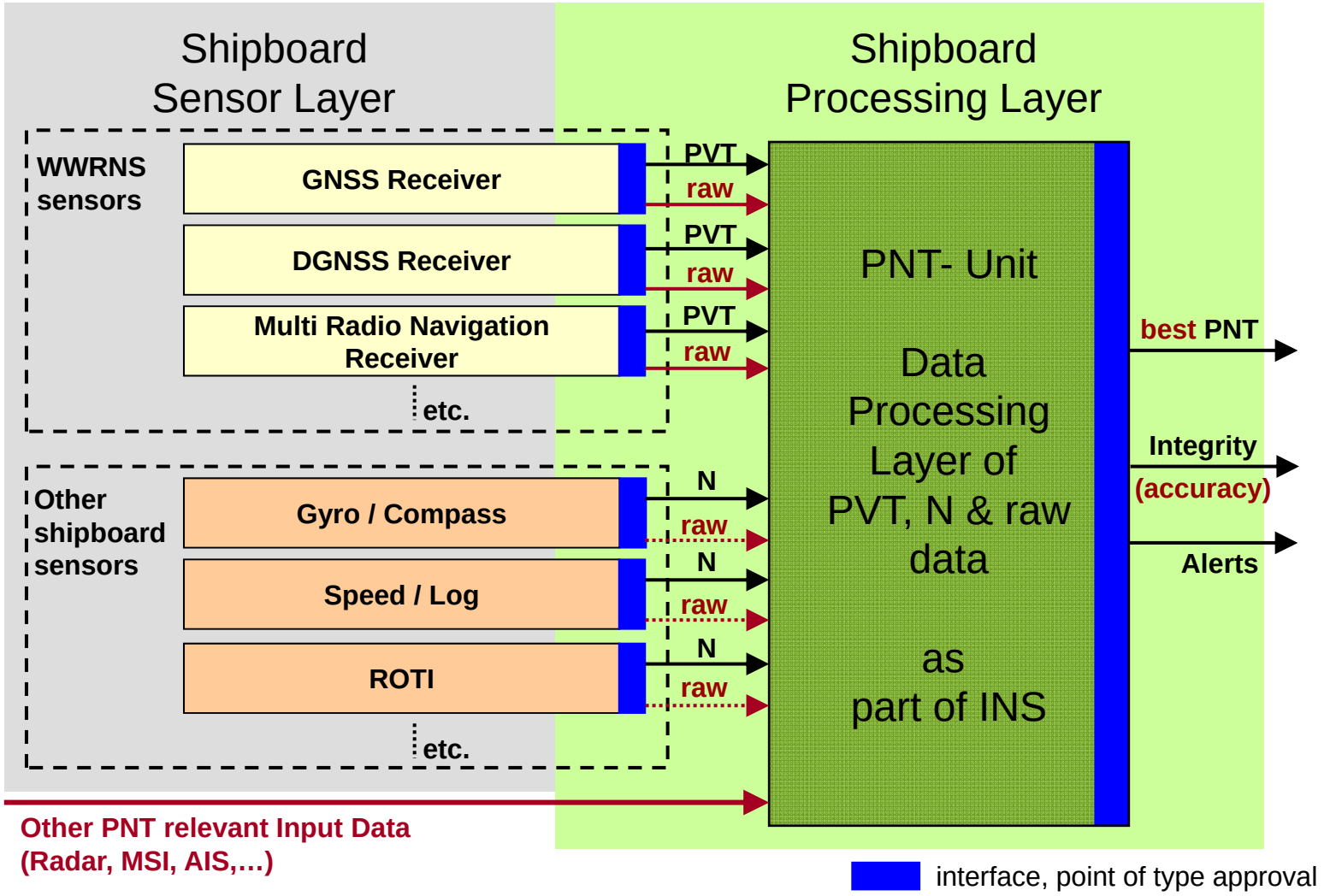
Captain is responsible for fusion of information from different sensors and displays

Current approach 2: Integrated Navigation System (INS)

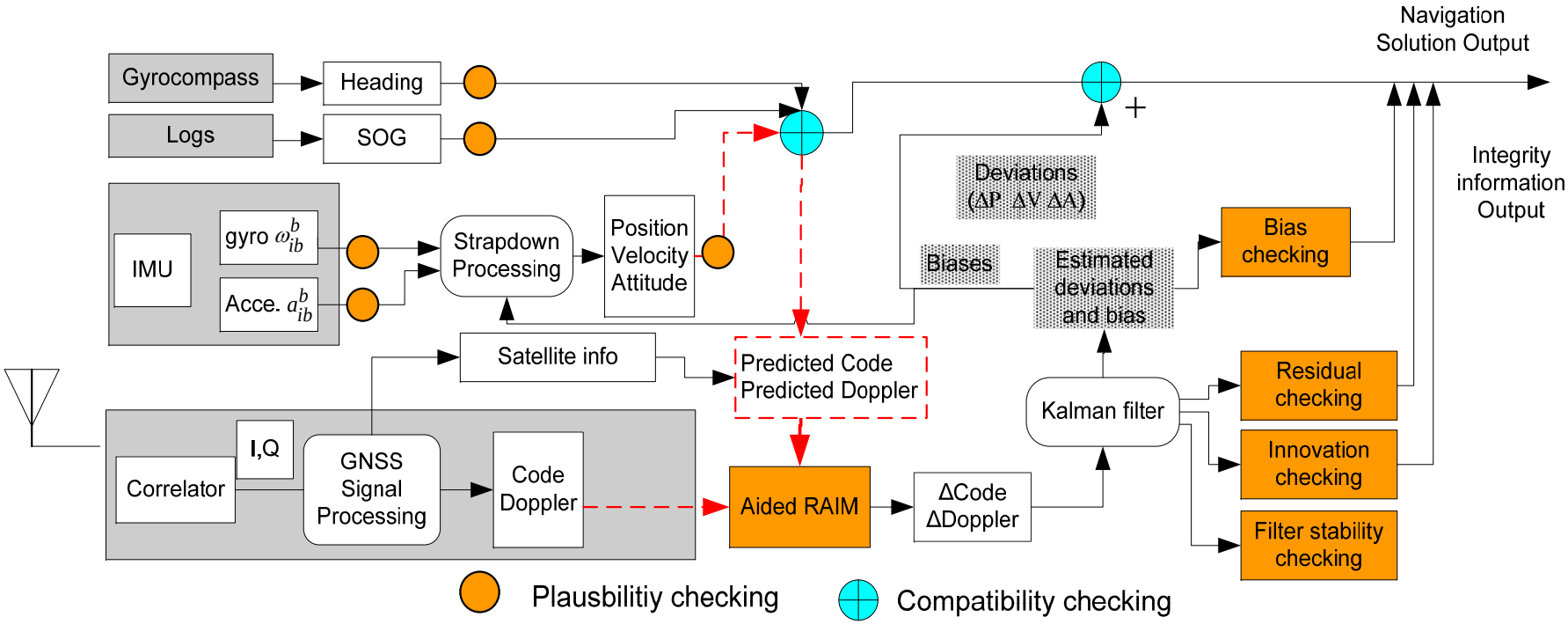


INS is not a mandatory system, but if it is installed it can replace single sensor requirements

The new PNT Unit Approach

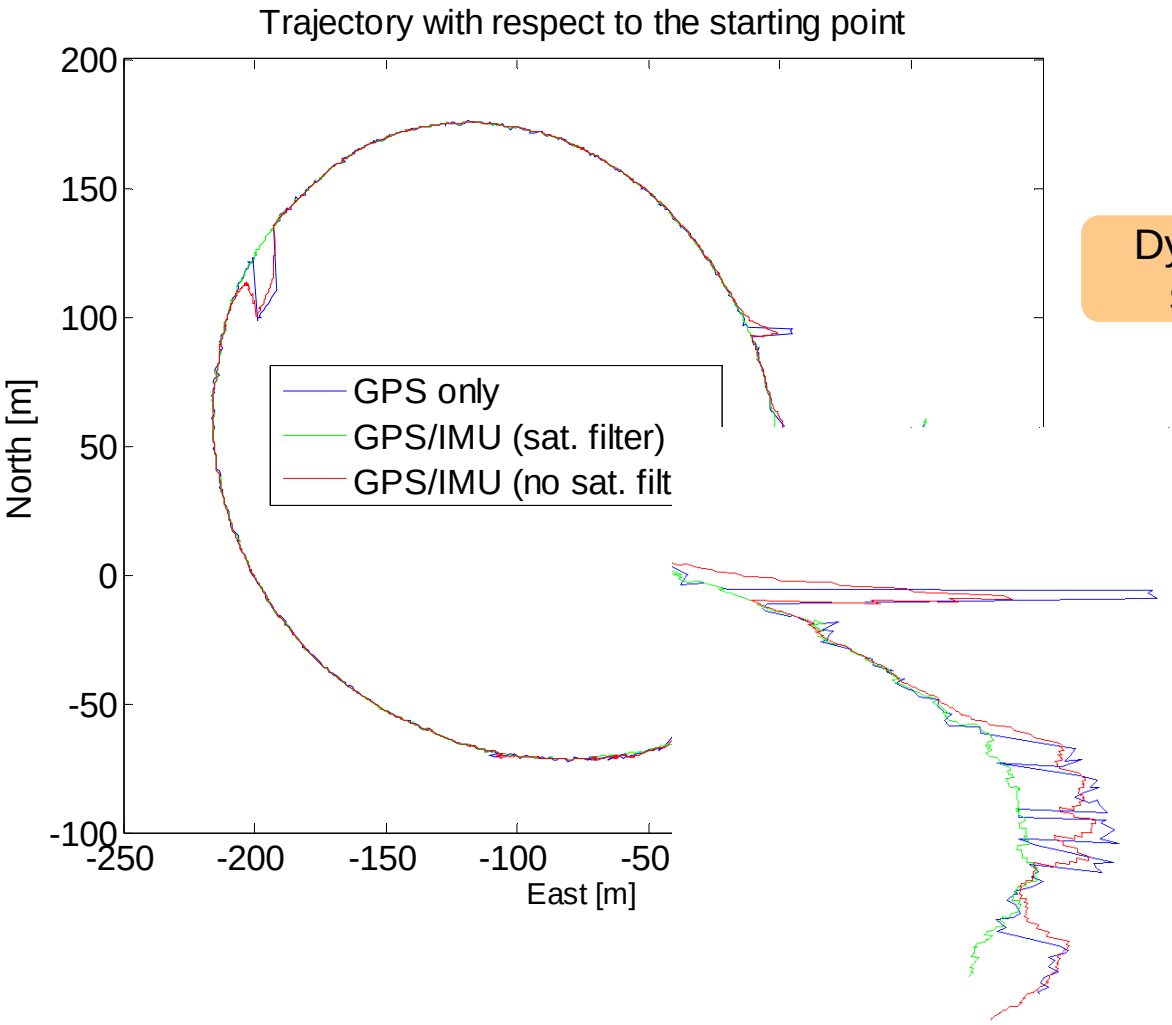


Position, Navigation and Timing Unit



Processing chains based on selected sensor set and accuracy assessment in real time

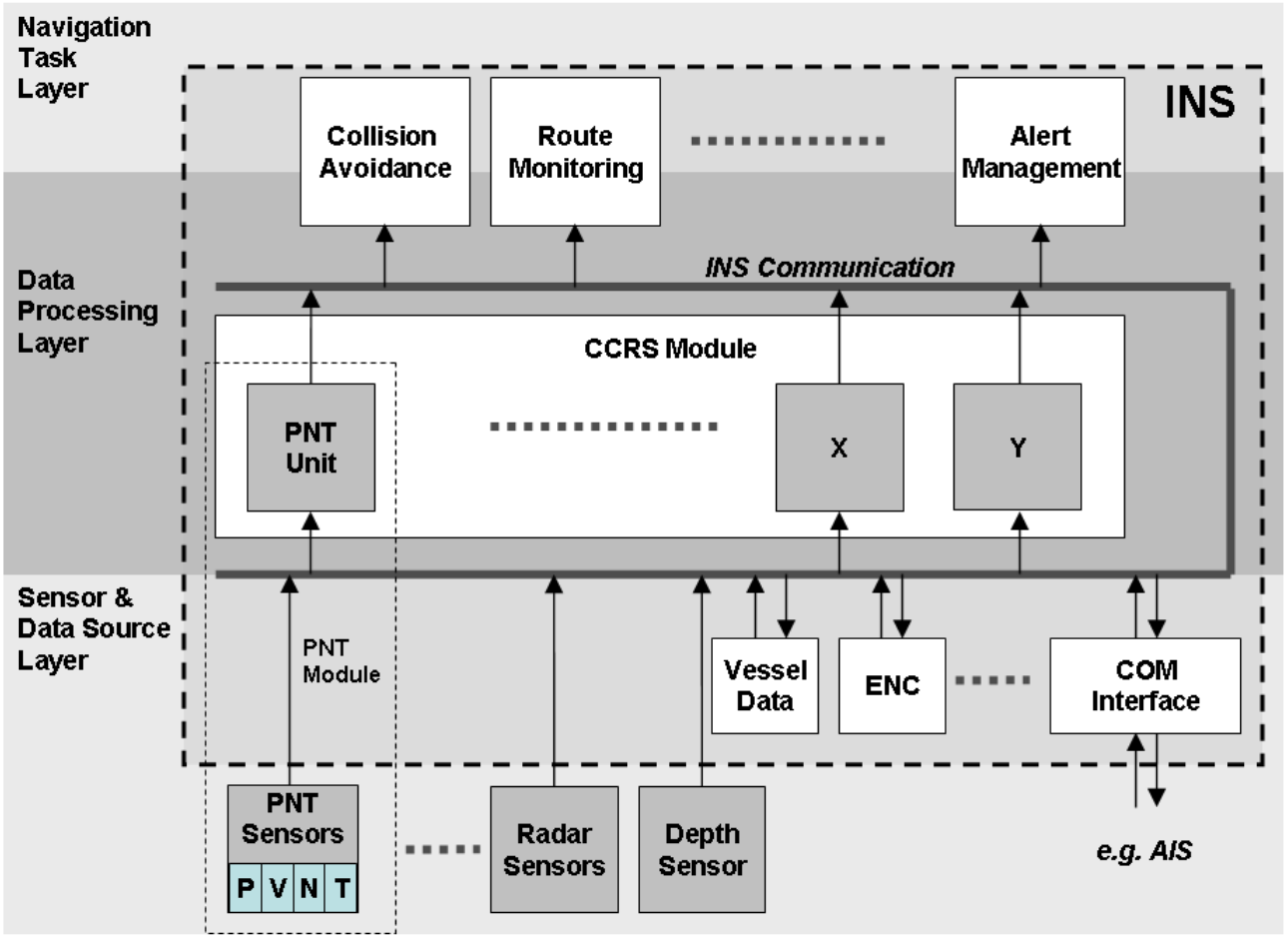
Estimation of reliable position with/without satellite filtering



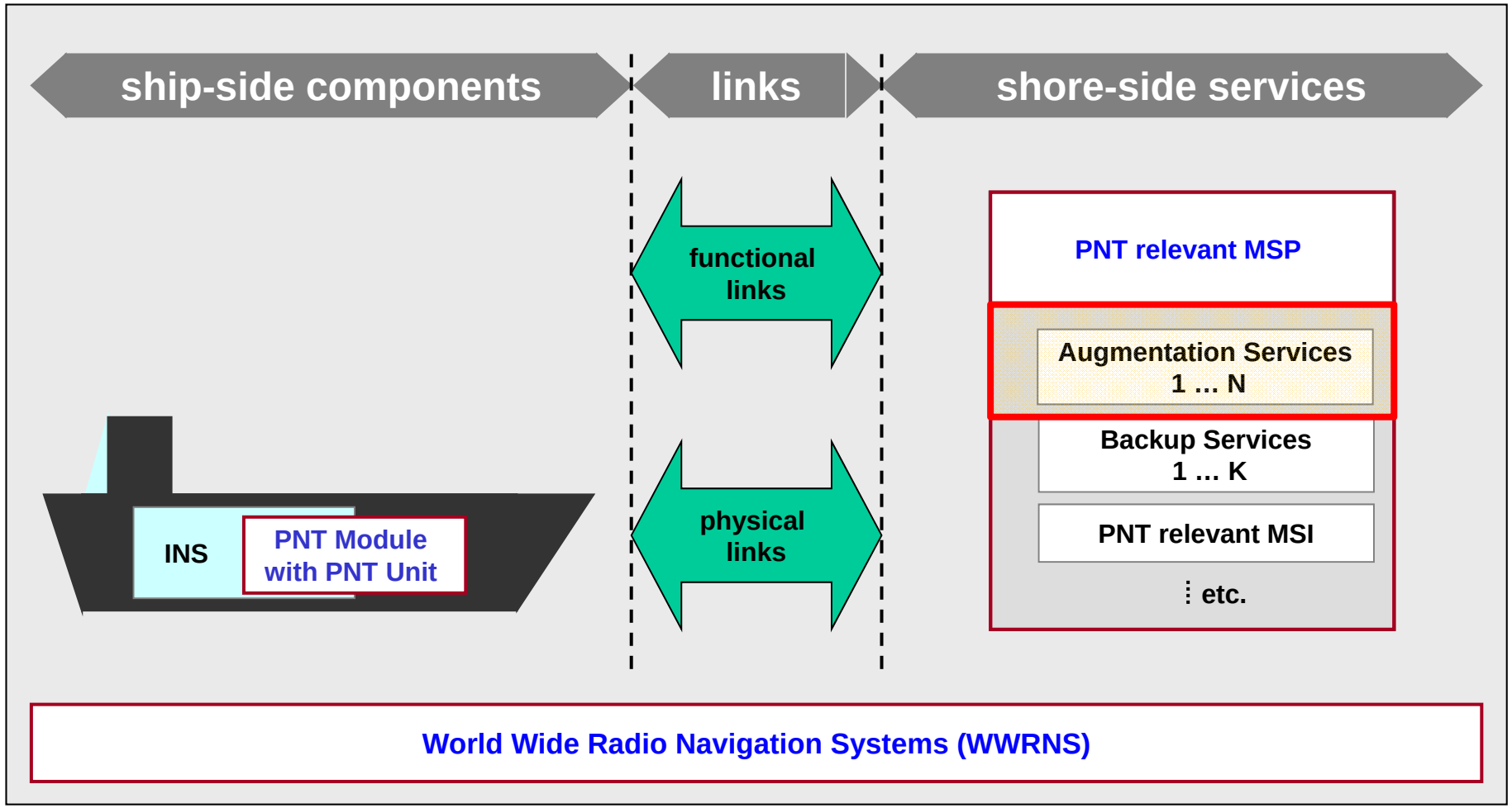
Dynamic model (herein IMU) can smooth the positioning results

rity monitoring on each
ment has dominant effects
e accuracy improvement

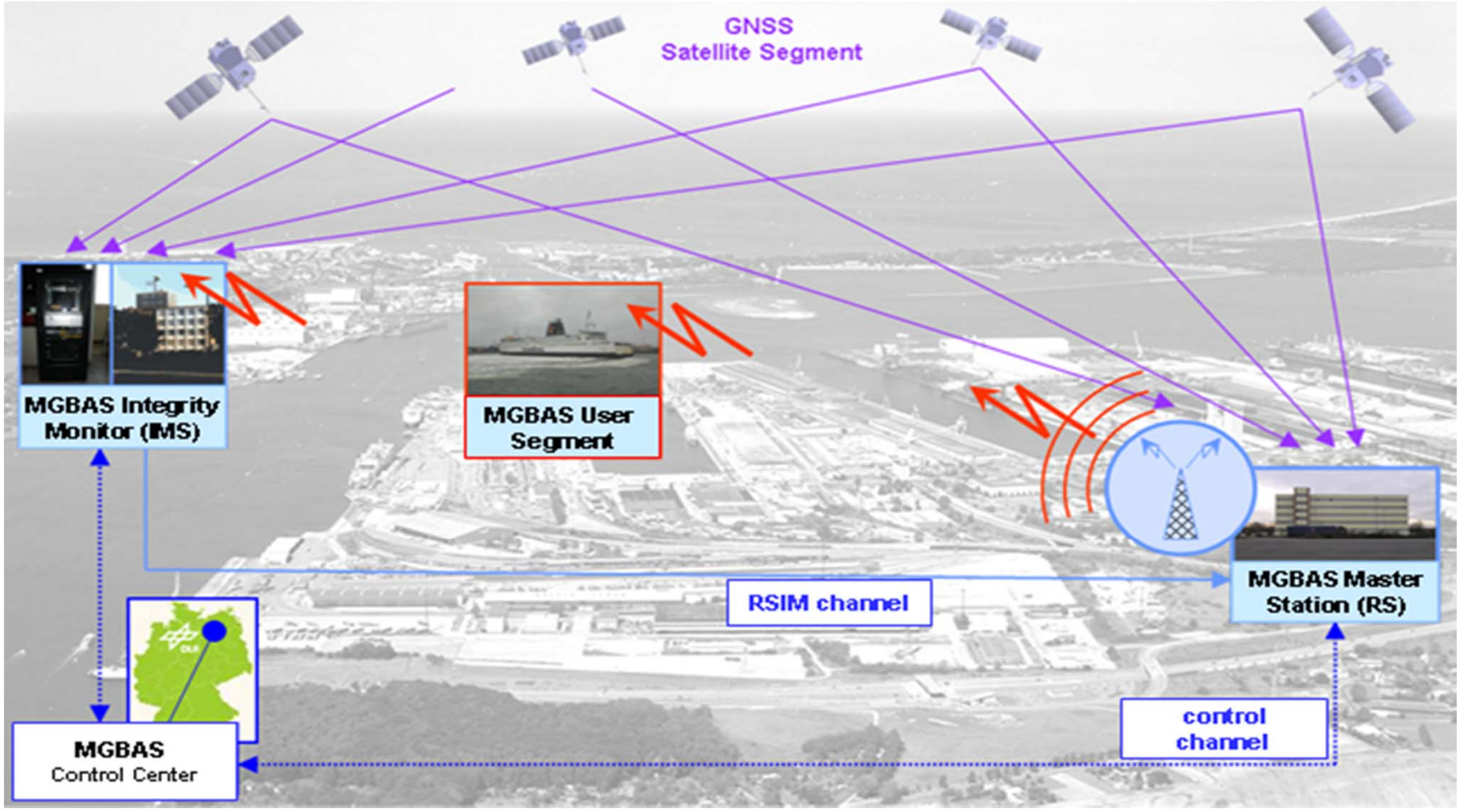
Implementation Approach of PNT Unit in INS



Generic Architecture of the whole PNT System



Maritime Ground Based Augmentation System (M-GBAS)



IMS = Integrity Monitoring Station
RS = Reference Station
GUT = GBAS User Terminal

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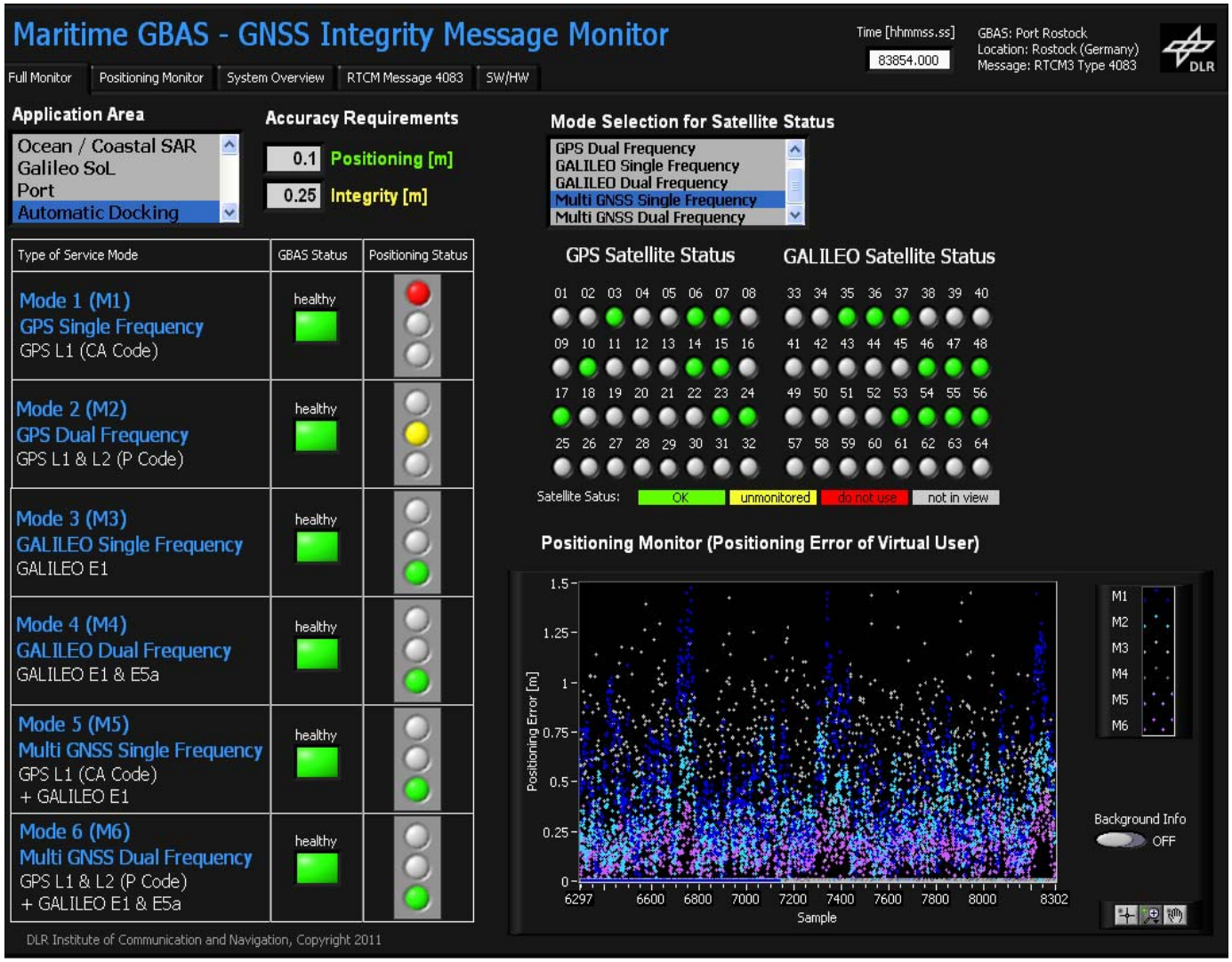
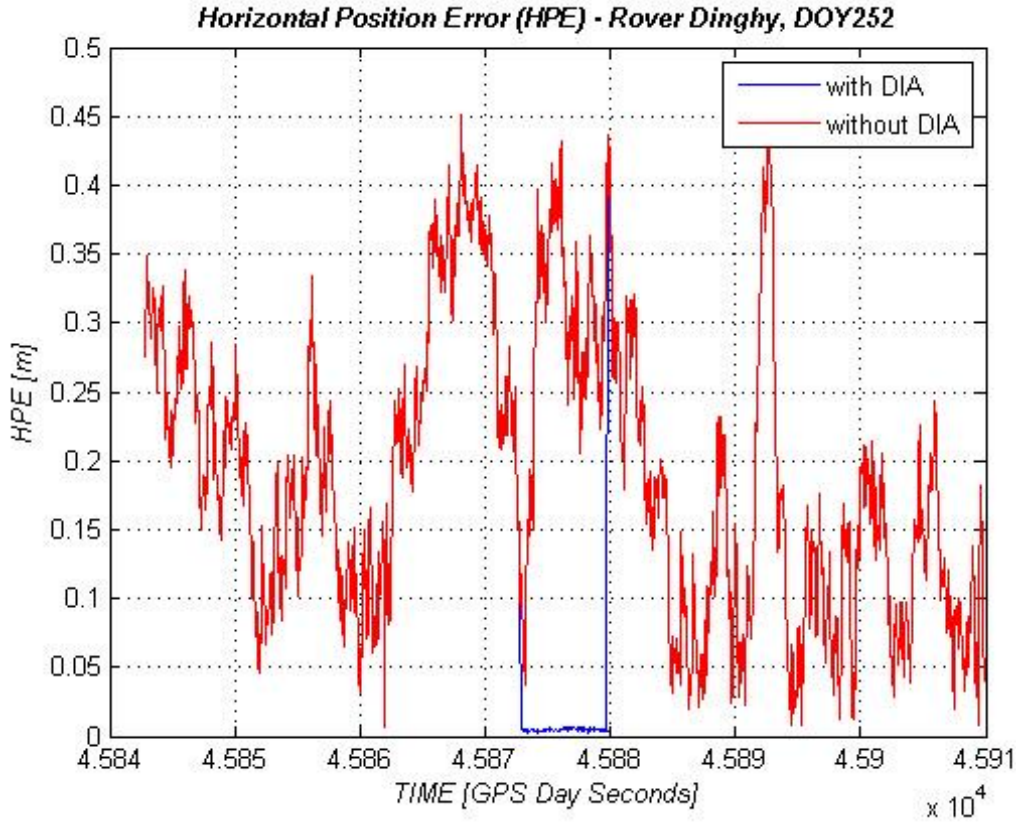
M-GBAS Integrity Message Monitor

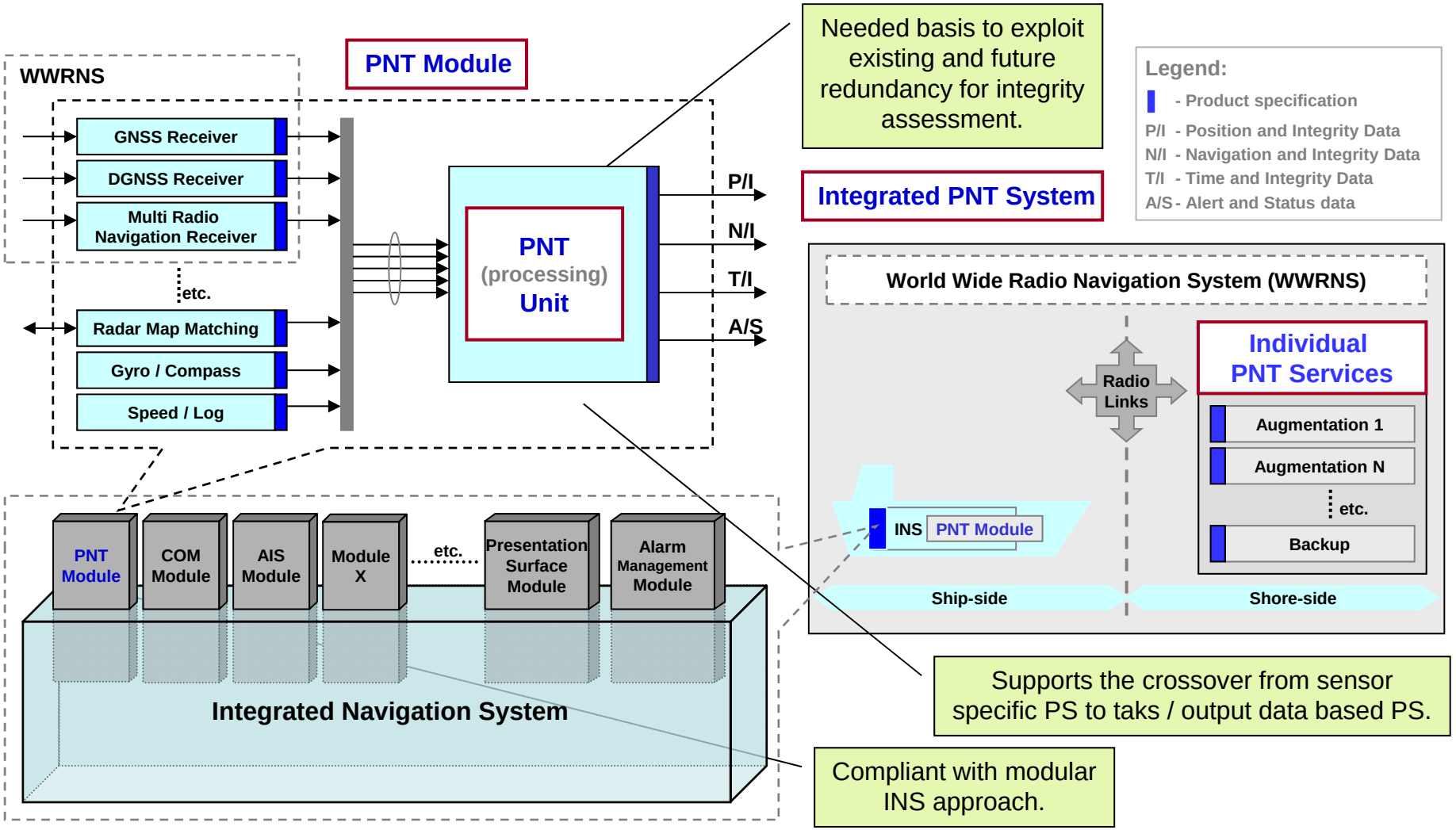


Using of M-GBAS at ship-board site

The effectiveness of applied integrity monitoring functionalities has been demonstrated that requirements on automatic docking can be fulfilled.



Concept of Integrated PNT System



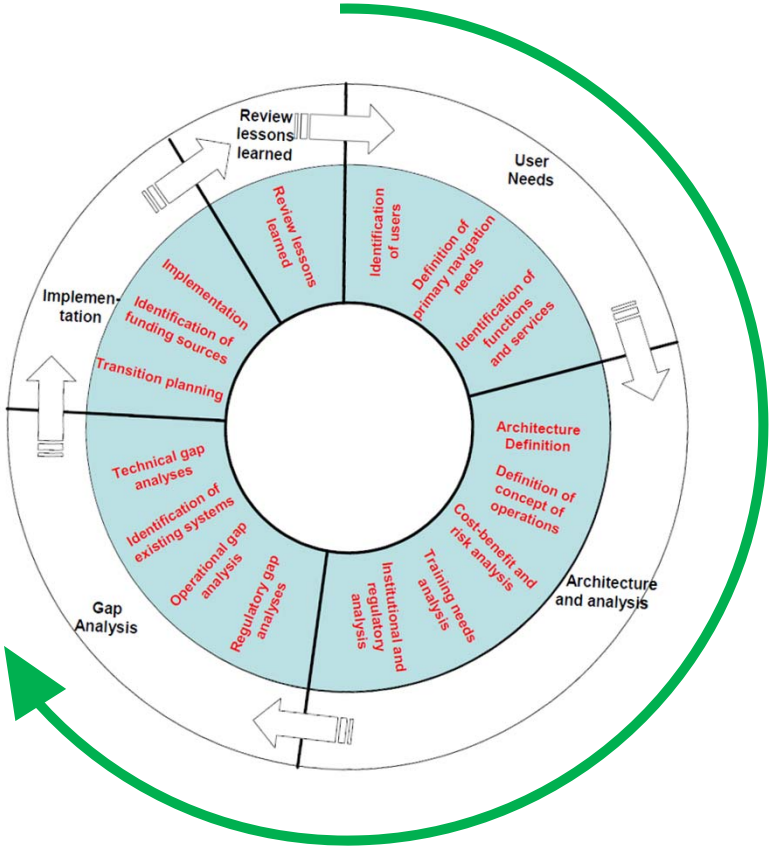
Do things in an international framework → E-Navigation

Definition

"e-Navigation is the harmonized collection, integration, exchange, presentation and analysis of maritime information onboard and ashore by electronic means to enhance berth to berth navigation and related services, for safety and security at sea and protection of the marine environment"

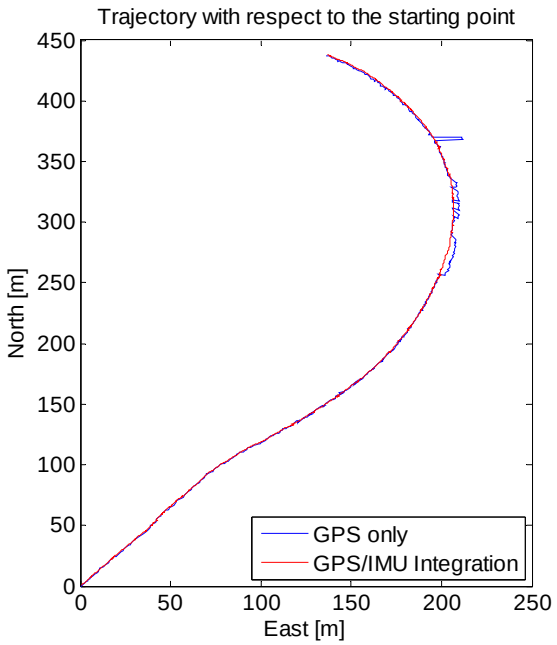
Core Elements (IMO NAV 24/15)

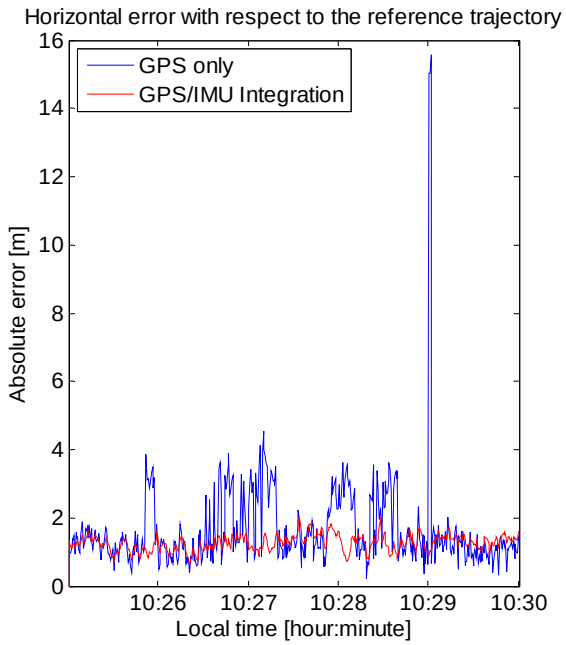
- Architecture
- HMI
- Convention & Standards
- Positioning Fixing
- Communication & Information
- ENC's
- Equipment Standardisation
- Scalability

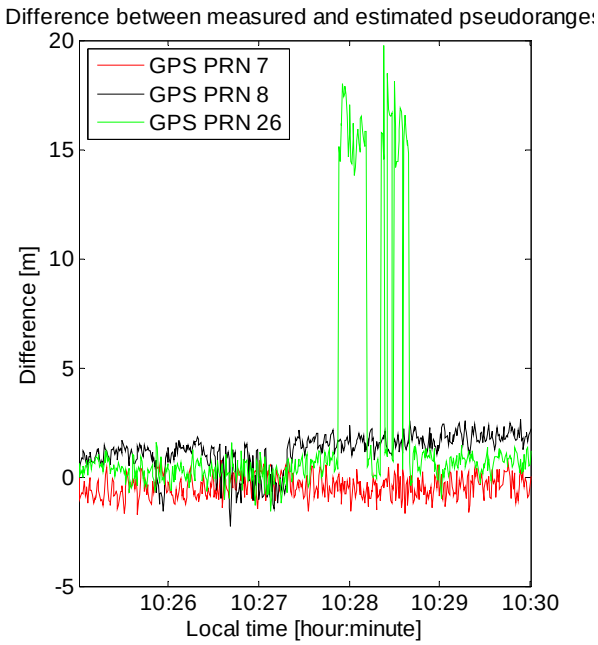


IMO-NAV54/25-Annex12:
E-Navigation Implementation Process

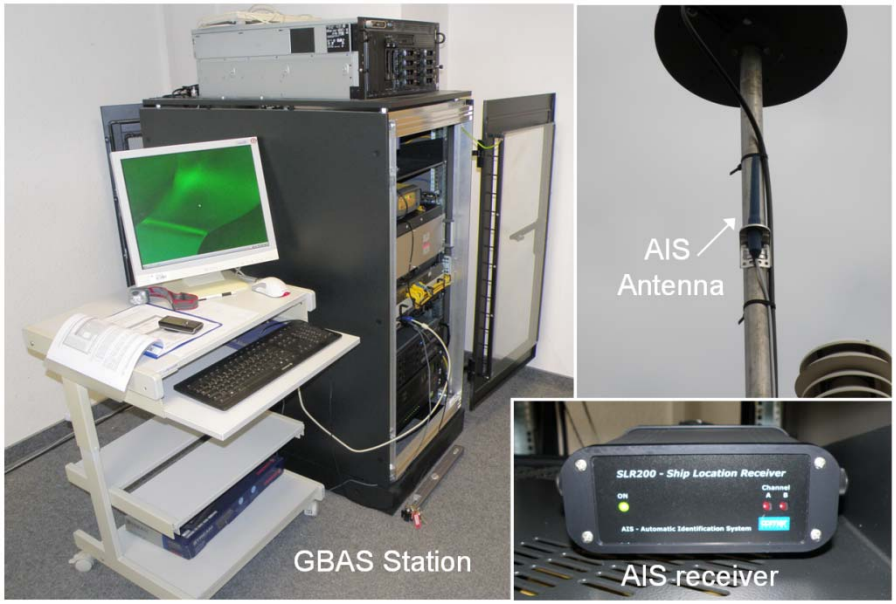
Position, Navigation and Timing Unit

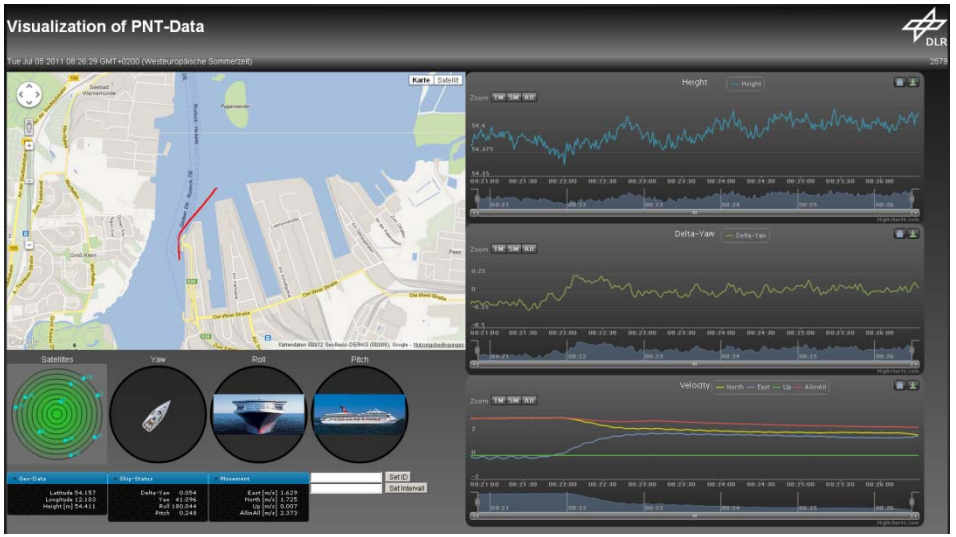


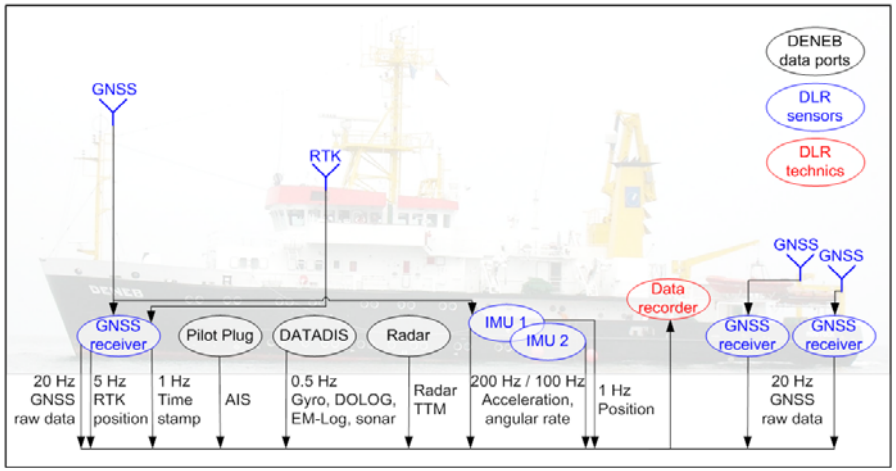




Real Time Traffic Situation Assessment Demonstrator







Development of own graphical tools and user interfaces for analysis and demonstration

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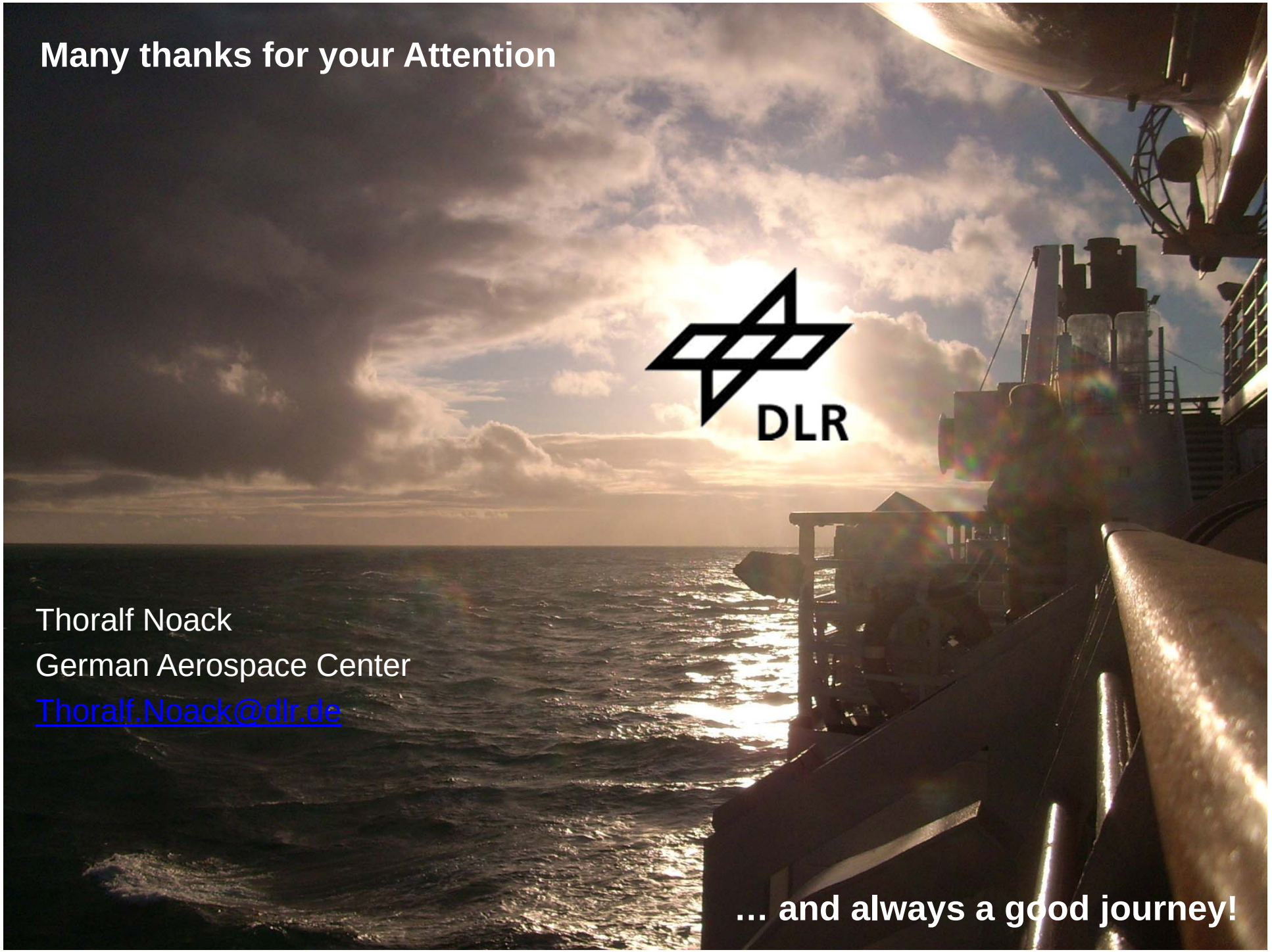
Summary

- Proposal: Integrated PNT System with PNT processing Unit
  - DLR initiative within IALA / IMO (E-Navigation)
- Integrity monitoring concept based error estimation using capabilities of sensor fusion techniques
- Integration of shore-site components to improve the reliability of used systems and services
  - Prototype of Maritime GBAS system at Research Port Rostock
- Status: PNT Unit demonstrator development
  - Different measurement campaigns
  - Characterization of single sensors
  - Algorithm development and test


Many thanks for your Attention
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… and always a good journey!